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Tipping Points for the Planet

Complex environmental systems are undergoing profound upheavals as a result of human activity.

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Burning to create pastureland for cattle in Mato Grosso State, Brazil. Victor Moriyama for The New York Times

By David Gelles and Manuela Andreoni

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A drumbeat of recent reports has driven home the fact that our planet's complex environmental systems are undergoing profound upheavals as a result of human activity.

Glaciers around the world, from Greenland to Switzerland to Antarctica, are melting faster than expected as atmospheric and ocean heat hit new highs.

New research suggests that up to half of the Amazon rainforest could rapidly transform into grasslands or weakened ecosystems in the coming decades as a result of deforestation, climate change and drought. Those stresses could eventually drive the entire forest ecosystem, home to a tenth of the planet's land species, past a tipping point that would trigger a forest-wide collapse.

And a new study suggests that a crucial network of ocean currents that carries warm water into the North Atlantic is showing early signs of collapse because of an influx of fresh water from melting glaciers.

All of these developments appear worrisome on the surface. But, most concerning of all, they raise the specter that the planet may be approaching some of the so-called tipping points that could trigger severe and irreversible changes.

Tim Lenton, a professor who studies climate and Earth systems at the University of Exeter, said tipping points were characterized by "amplifying feedback within a system that's getting strong enough that it can cause a self-propelling change."

What that means in layman's terms: Once the key threshold is crossed, the change accelerates, and a profound transformation becomes inevitable. Change begets more change in a self-reinforcing loop.

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Amazon rainforest. Up to half of the Amazon rainforest could transform into grasslands or weakened ecosystems in the coming decades, a new study found, as climate change, deforestation and severe droughts damage huge areas beyond their ability to recover. Those stresses in the most vulnerable parts of the rainforest could eventually drive the entire forest ecosystem past a tipping point that would trigger a forest-wide collapse, researchers said.

There is no consensus that any large-scale tipping points have been reached, though there is debate about whether some, on the Greenland ice sheet and in many of the world's coral reefs, are close or have already tipped.

"Things that we actually observe happening in the climate look a whole lot like tipping point changes, or serious harbingers of those changes," Lenton said.

The planet's tipping points

The phrase "tipping point" has a complicated and controversial history. Scientists started talking regularly about climate tipping points in the early 2000s. They quickly concluded that some of those tipping points were fast approaching, or might have already passed.

The self-propelling mechanism of tipping points are typically made up of various feedback loops. Here are examples of how some of them work.

- Some of the most worrisome concern the world's vast ice sheets.

If the Greenland ice sheet collapses, for example, global sea levels could rise by seven meters, or 23 feet, over the next centuries. **Feedback loops:** As the ice melts, its surface declines in altitude, which means the air on top of it is warmer, leading to more melting. And, disappearing ice means fewer white surfaces to reflect sunlight back into space, which warms the atmosphere even more.

- Thawing of permafrost could release gigatons of planet-warming methane into the atmosphere. **Feedback loop:** Methane causes the atmosphere to warm further, melting more permafrost, and so on.
- Earth's ecosystems — such as forests, coral reefs and lakes — are in danger, too, with far-reaching consequences. For example, the collapse of boreal forests, which burned at an unprecedented rate last year, could send enormous amounts of carbon into the atmosphere. **Feedback loop:** Fires create water stress, reducing the ability of trees to resist insect infestation, which makes them more vulnerable to fires.
- Currents and monsoons that regulate the oceans and the atmosphere can slow down, warm up and shift in all sorts of ways. If the currents that bring warm water to the North Atlantic collapse, for example, average temperatures in Western Europe could plummet in a matter of decades. **Feedback loop:** These currents move saltier water from one part of the ocean to another. If they become weaker, less salt is transported, the surface water becomes less salty, which makes it less dense and less likely to sink, weakening currents further.

Since researchers started identifying tipping points, the list of systems that are close to the edge has grown steadily to the current two dozen; some closer, some farther from collapse. You can check them all out in a report about global tipping points that Lenton and his colleagues published a few months ago.

Good tipping points

It's not only the planet that can experience tipping points. There are industrial, technological and economic tipping points, too. And some of them might help curb global warming.

Take the rapid decline in costs for renewable energy. Last year, we

reported on a study that argued solar power had already passed a tipping point because market forces alone, with no help from policymakers, could make it the cheapest source of electricity by 2027. Similar dynamics could benefit wind power, batteries and other parts of the clean energy transition.

The new economics of green energy is leading to an influx of spending in the sector. Last year, for the first time, total global investments in solar were greater than investments in oil.

Solar panels, wind turbines and batteries are all experiencing startling gains in efficiency, too. And, the adoption of electric vehicles and heat pumps continues to rise as they become more affordable.

Lenton, who is writing a book about tipping points, noted that social norms could rapidly change, as well, practically overnight. (The phrase "tipping point" was used in social science to describe a sudden rush of white families moving out of a given neighborhood as Black families moved in.)

Some people believe that we may see the animal farming industry we have today as unacceptable in the future. Could eating meat every day be frowned upon in the future? Will burning fossil fuels ever become unthinkable?

"Sometimes change really is self-propelling, and something huge happens out of nowhere," Lenton said. "It could be really bad, if it's bad. But it can also be very good, if it's good."

In Palm Springs, Calif., the Mesquite Golf & Country Club was converted into the Prescott Preserve in the last few years. Ariana Drehsler for The New York Times

Rewilding the golf course

Shuttered golf courses around the country are being transformed into nature preserves, parks and wetlands. Among them are sites in Detroit, Pennsylvania, Colorado, the Finger Lakes of upstate New York, and at least four in California.

Though rewilding a golf course may disappoint players, it can bring big benefits to animals, plants and non-golfers. On a stretch of land owned by the University of California, Santa Barbara, the 64-acre spread that was once the Ocean Meadows Golf Course is

now an estuary surrounded by grasslands, a salt marsh and islands of coastal sage scrub. Two federally endangered plants, the Ventura marsh milkvetch and the salt marsh bird's beak, have also been established on the site, part of an effort to move some plants north as their natural habitats grow too warm.

For a golf course to be turned into a public green space, an unlikely set of stars need to align. There has to be a willing seller, and, crucially, a conservation-minded buyer who can afford to not just purchase the land but to restore it. But the numbers are growing. Between 2010 and October 2022, some 28 former courses were transformed into public green spaces. — *Cara Buckley*

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